SECTION C

(Calculations 10 marks each - spend up to 36 minutes)

16. An unconfined fresh water aquifer [the density of water can be assumed to be 1,000 kg/m^3] has a thickness of 23 m at the location of a piezometer installed to a total depth of 16 m. The land surface elevation at the piezometer is 98 m above sea level, and the measured depth to water is 6.5 m below the ground surface. What is the total hydraulic head for the aquifer? What is the pressure head and elevation head at the base of the aquifer?
17. The unconfined aquifer described above is underlain by a thin confining layer and a second aquifer that is 64 m thick. The lower aquifer has a monitoring well that has a land surface elevation of 99 m, with a total well depth of 80 m below ground surface. The measured water-level in this well is 7.8 m below ground surface, and the density of the salt water is 1,035 kg/m^3. What is the equivalent fresh water head for this aquifer?
18. A waste disposal company has applied for a permit to inject PCB's into the lower aquifer. Is this a good place to store hazardous waste? Why?
19. An earth dam is constructed across a valley that has a very low permeability bedrock layer. The dam is 45 m high with a crest-width of 100 m and a width at the base (valley floor) of 900 m. The valley is 5 km wide. The water behind the dam is 40 m deep, and the water level below the dam is 5 m above the bedrock valley floor. Water seeps through the dam Assume that the dam is constructed of silty clay. What is the hydraulic head at a point half-way through the dam?
20. How much water would flow through a unit width of this dam in one day? [Hint: You have to assume the properties of a silty clay.]
21. How much water would flow through the dam in m^3/d?

THE END

University of Saskatchewan
Department of Civil and Geological Engineering

GEOE 475.3 Advanced Hydrogeology

MIDTERM EXAMINATION

Date: 25 October, 2002
Time Allowed: 1 hour
Instructor: Dr M. J. Reeves

ANSWER ANY FOUR QUESTIONS

1. An unconsolidated sand and a sandstone have a measured hydraulic conductivities of 10^{-1} and 10^{-5} m/s respectively. The sand is has an effective porosity of 20%. The sandstone has an effective porosity of 0.5%. For material, determine the time in years for a tracer to be advected 100 m under an imposed hydraulic gradient of 1m/km.

2. A continuous source contaminant enters a groundwater flow-field where the horizontal velocity is 10^{-6} m/s. In the horizontal plane, the longitudinal and transverse dispersivities are 5.0 m and 0.5 m respectively. Determine the distance travelled by the centre of mass of the plume and the spatial standard deviations of the plume a period of 10 years after the spill.

3. Use the Debeye-Hückel equation (A = 0.5085) for activity coefficients to calculate the activity coefficient for the Cl^- ion (effective radius = 0.18 nm) and the Mg^{2+} ion (effective radius 0.40 nm in a 0.5 molar solution. Repeat the calculation using the extended Debeye-Hückel equation with B = 3.281. Using the calculated activities, determine the effective concentrations of $[Mg^{2+}]$ and $[Cl^-]$ in a 0.5 M ionic strength solution of $MgCl_2$.

4. Write mass law expressions for the following equilibrium reactions:

   1. $CaMg(CO_3)_2 = Ca^{2+} + Mg^{2+} + 2CO_3^{2-}$
   2. $H_2SO_4 = 2H^+ + SO_4^{2-}$
   3. $aA + mB + nC = aX + bY + cZ$
   4. $Al(OH)_3 = Al^{3+} + 3\ OH^-$
   5. $Al_2Si_2O_5(OH)_4 + 5\ H_2O = 2\ Al(OH)_3 + 2H_4SiO_4$

5. Given the constituents as molarities:

	Na^+	Mg^{2+}	Ca^{2+}	Cl^-	HCO_3^-	SO_4^{2-}
Molarity	1.1×10^{-2}	9.0×10^{-4}	1.5×10^{-3}	3.2×10^{-4}	1.5×10^{-3}	2.2×10^{-4}

GEOE 475.3 Advanced Hydrogeology

MIDTERM EXAMINATION

Date: 17 October, 2001
Time Allowed: 1 hour
Instructor: Dr M. J. Reeves

ANSWER ANY THREE FOUR QUESTIONS

1. Two tills both have a measured hydraulic conductivity of 10^{-7} m/s. One till is unfractured and has an effective porosity of 25%. The other till is fractured and has an effective porosity of 0.25%. For each till, determine the time in years for a tracer to be advected 20 m under an imposed hydraulic gradient of 1m/km.

3. A point source contaminant spill was released to groundwater flowing at a constant sub-horizontal velocity of 5 x 10^{-6} m/s. In the horizontal plane, the longitudintal and transverse dispersivities are 1.0 m and 0.1 m respectively. Determine the distance travelled by the centre of mass of the plume and the spatial standard deviations of the plume a period of 5 years after the spill.

5. Four complete water sample analyses reported the following results.

Ion	Formula	Sample A	Sample B	Sample C	Sample D
	Weight	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Na^+	22.99	69	1494	115	46
Cl^-	35.45	71	142	142	71
SO_4^{2-}	96.06	96	120	48	<1
Conductivity	(mS/m)	143	220	269	65

Check the analyses and report any significant errors. Are the reported electrical conductivities consistent with the reported concentrations?

7. The extended Debeye-Hückel equation for activity coefficients has the form: $\log(\gamma_i) = -0.5085\ z^2 (I)^{0.5} / (1+3.281a_i (I)^{0.5})$ where z is ionic charge, a_i is ionic radius (nm) and I is ionic strength (mol/L). For an ionic strength of 0.1 M, calculate the activity coefficient for the Cl^- ion (effective radius = 0.181 nm) and the Mg^{2+} ion (effective radius 0.065 nm). Using the calculated activities, determine the effective concentrations of $[Mg^{2+}]$ and $[Cl^-]$ in a 0.1 M ionic strength solution of $MgCl_2$.

8. Write mass law expressions for the following equilibrium reactions:

   a. $CaCO_3 = Ca^{2+} + CO_3^{2-}$

   b. $Mn^{2+} + Cl^- = MnCl^+$

   c. $MgCl_2 = Mg^{2+} + 2\ Cl^-$

   d. $Al(OH)_3 = Al^{3+} + 3\ OH^-$

   e. $Al_2Si_2O_5(OH)_4 + 5\ H_2O = 2\ Al(OH)_3 + 2H_4SiO_4$

11. Tabulate the constituents as molarities using the formula weights provided.

	Na^+	Mg^{2+}	Ca^{2+}	Cl^-	HCO_3^-	SO_4^{2-}
meq/L	10.88	1.80	3.08	0.32	14.66	0.44
FW	22.99	24.03	40.08	35.45	61.01	96.06

Calculate the saturation indices for the minerals Halite (NaCl), $K_{sp} = 10^{1.58}$; Nahcolite ($NaHCO_3$), $K = 10^{-0.148}$ and Gypsum ($CaSO_4$, $K_{sp} = 10^{-4.62}$)

THE END

GEOE 475.3

Formula Sheet
(No explanations of symbols is are provided)

- $q = K.i$
- $v = K.i / n$
- $D_d^* = D^*.D_d$
- $D_d^* = (\alpha/\tau).D_d$
- $D_L = \alpha_L.v$
- $D_T = \alpha_T.v$
- $D = D^* + D_d^*$
- $\sigma = (2Dt)^{1/2}$
- $D_L = \sigma_L^2 / 2t$
- $D_T = \sigma_T^2 / 2t$
- $D_L = \alpha_L.v / 2x$
- $\sigma_L^2 = v^2.\sigma_t^2$
- $D_L = v^2.\sigma_t^2 / 2t$
- $2\sigma_t = (t_{81} - t_{16})$
- $\sigma_T = \Gamma_c / 2.345$
- $\Gamma_T = \Gamma_n.v$
- $\rho(h) = \exp(-|h|/\lambda)$
- $A_L = \sigma_L^2.\lambda / \gamma^2$